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ABSTRACT

A study was conducted at the International University of Japan to see if second language (L2) working capacity correlates with L2 reading ability in advanced English-as-a-Second-Language (ESL) learners. The study consisted of a set of memory tests (Simple Digit, Simple Word, and Complex Span Test) and a set of measures of reading skills given to 32 students, with similar educational backgrounds, who were attending the university. Analyses of the data acquired from the various tests suggested a correlation between L2 working memory capacity and reading ability. Additionally, it was found that the L2 Complex Word Span measure correlated with measures of L2 reading skills, particularly the Test of English as a Foreign Language reading score and, thus, can serve as a useful measure in L2 reading development. It was established that if the working memory construct is to be of explanatory value in L2 (or L1) research, it will be necessary to demonstrate a causal, non-circular relationship between working memory capacity and the development of reading skills. The ultimate usefulness of the construct will depend on the degree to which working memory capacity can be established independent of the level of proficiency. In order to address this issue, converging evidence from multiple measures of working memory capacity and reading skill are needed. Contains 21 references. (GLR)

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WORKING MEMORY IN L2 READING: DOES CAPACITY PREDICT PERFORMANCE?[1]

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A complete theory of second language acquisition must accommodate the fact that L2 acquisition and use represents a complex cognitive skill. As a complex skill L2 acquisition is subject to the same general cognitive principles that constrain the acquisition of new motor skills or new knowledge in a particular domain. One profound constraint on the learning and execution of such skills is the limitation placed by memory on the rate, quantity and long term retention of information processed. In L2 learning and use these limitations have an effect on the rate of attainment and ultimate learner success (McLaughlin, 1987).

However, the fact that the L2 learner is a limited capacity processor is, by itself, of little interest. Rather, what is of interest is identifying and explaining the nature of the capacity limitations and how these limitations manifest themselves in the L2 acquisition process. A better understanding of the mechanisms that define such limitations will provide insight into why second language acquisition unfolds the way it does, and why pronounced individual differences in learning rates and outcomes are often evident.

The research reported today investigates the relationship between working memory and reading ability in the L2. The working memory construct represents one of the most explicit attempts to provide a qualitative and quantitative account of one type of general capacity

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limitation. Working memory as we will use it here refers to the immediate memory processes involved in the simultaneous storage and processing of information in real-time. The notion has been developed most fully in the individual differences literature, particularly in context of L1 reading (Baddeley, 1986; Carpenter, & Just, 1989). In this paper we will examine the relevance of working memory to L2 reading, and will present some data that suggests a similar relationship between L2 working memory capacity and reading ability.

The first part of the paper will present a brief overview of the working memory construct and prior research in the area. This will be followed by a discussion of the potential relevance of working memory issues to L2 and a set of research questions motivating the study. In the second part of the presentation we will present data from a study that examines the relationship between L2 working memory capacity and reading ability in advanced Japanese ESL learners.

The term *working memory* is often used interchangeably - and misleadingly - with short term memory. In the traditional view, short-term memory was viewed as a static, relatively passive store for temporary information. Of essentially fixed capacity, information was retained in the short term store for a brief period (anywhere from 4 to 30 seconds), from where it was either forgotten or transferred to long term storage as knowledge (Waugh, & Norman, 1965).

Baddeley and Hitch (1974) suggested that this model focused too much on the static storage functions not enough on the processing functions involved in the immediate on-line processing of information. They proposed that the term *working memory* be adopted to underscore the importance of both storage and processing in immediate memory. Working memory is thus defined in primarily functional - rather than structural - terms. Baddeley and Hitch proposed that the working memory system consists of (1) a central executive (2) an articulatory loop, and (3) a visuo-spatial scratchpad. The articulatory loop and the visuo-spatial scratchpads are maintenance systems for processing and holding acoustic and visual information, respectively. The two systems are controlled by the central executive, which is a flexible work space with limited capacity. A portion of this limited capacity is used for processing incoming information with the remainder used for storage of the products resulting from that processing (Baddeley, & Hitch, 1974). Available capacity is thus a

function of the trade-off between storage and processing demands. The total capacity available is assumed to be relative to the task as well as to the individual.

Daneman and Carpenter (1980) proposed that individual differences in L1 reading ability can partially be explained by differences in working memory capacity. Reading skill is a particularly appropriate skill for testing the working memory construct as it is paradigmatic of a complex cognitive skill. Skilled reading requires both the continuous processing of new information and the simultaneous retention and integration of intermediate products of text comprehension, e.g., anaphoric reference, long distance dependencies. If reading skill is sensitive to capacity limitations, then the good reader should have a larger working memory capacity than her less skilled counterpart. This capacity advantage is assumed to be the result of more efficient processing skills, This, in turn, allows more capacity resources to be devoted to the continuing activation (storage) of the intermediate products of comprehension during on-line processing. It is the ability to simultaneously process and retain multiple informational cues that distinguish the skilled reader from the less-skilled.

Daneman and Carpenter (1980) demonstrated that working memory capacity did correlate with measures of overall reading comprehension, as well as with specific reading skills such as being able to understand pronominal reference, and the ability to extract particular facts from a text (Daneman, et al., 1980; Daneman, & Carpenter, 1983). As an index of working memory capacity in reading they developed *The Reading Span Test*, a concurrent memory task designed to tap both processing and storage functions of working memory. The Reading Span Test will be adapted and used in the present study. In the original version of the task the subject is instructed to read each sentence aloud while trying to remember the last word of each sentence. After the set of sentences is read the subject is given a prompt and attempts to recall as many of the final words as possible. The size of the sets range from two to eight sentences per set. Capacity is measured by the number of words correctly recalled (Daneman, et al., 1980).

Working memory capacity, as indexed by the Reading Span Test measure, was shown to correlate with measures of global reading profiency such as the verbal SAT and the Nelson-Denny Reading Test (r = 4. to 6.). For more specific reading tasks like identifying pronominal

antecedents, the correlations reached as high as r = .9. Also, while the subjects' Reading Span measures correlated with level of reading proficiency, their simple memory span measures did not. These traditional measures of short-term memory index the ability to remember random strings of digits, words, etc.(Miller, 1956), and their lack of correlation with reading ability has been demonstrated (Perfetti, & Goldman, 1976). This lack of correlation of the simple span measures, coupled with the correlations of the complex Reading Span measure, is important because it provides a form of discriminant validity for the Reading Span Test as a measure of both processing and storage functions.

Daneman and Carpenter's (1980) results have been replicated a number of times (Daneman, et al., 1983; Daneman, & Green, 1986; Daneman, & Tardif, 1987; Oakhill, Yuill, & Parkin, 1986; Turner, & Engle, 1989; Yuill, Oakhill, & Parkin, 1989). The immediate objective of the study is to see if the relationship between working memory capacity and reading skill evident in L1 readers is also evident readers in the L2. There are several reasons why the working memory construct is of potential interest to L2 researchers. The first is that it provides an explicit, testable account of processing limitations. Working memory capacity is a plausible source of processing constraints proposed to account for L2 developmental sequence (Pienemann, & Johnston, 1987). Also, as a reflection of individual differences cognitive processing, working memory capacity can also contribute to our understanding of aptitudes and abilities for L2 learning (Skehan, 1989). And finally, evidence from L2 reading can provide insights into the working memory construct itself. By examining cross-linguistic data within subjects we should be able to gain greater insight into what, if any, causal relationship working memory capacity plays in the development of L2 proficiency.

The study reported today examines L2 working memory and its relationship with L2 reading. We will present evidence indicating the same pattern of correlations among memory and comprehension measures as obtained in L1 reading. Such findings represent a minimum, yet necessary, condition for establishing a role for working memory capacity in L2 processing.

The Study

The goal of this study was to see if L2 working capacity correlates with L2 reading ability in advanced ESL learners. The measure of working memory we will use is the Complex Word Span Test, an adaptation to the Reading Span Test developed by Daneman & Carpenter (1980). As indicated above, we are interested in obtaining a dissociation between, on the one hand, the correlations of the simple memory tests with the reading measures and, on the other hand, the correlations of the complex span test with the reading measures. The presence of a dissociation in the correlations between L2 reading skill and the respective Complex Word Span and simple memory span measures will be taken as evidence for the sensitivity of the complex span (as an index of working memory capacity) to individual differences in L2 reading ability. Conversely, a failure to replicate the dissociations obtained with L1 readers would raise questions as to the applicability of complex span tasks in particular, and the working memory construct in general, to L2 reading research. This is recognizing, of course, the usual caveat as to problematic nature of interpreting null effects.

Method

Subjects. The study was carried out at the International University of Japan, an English-medium graduate institution in Niigata, Japan. The 32 subjects who participated in the study were students in the university's Intensive English Program, a 10-week summer intensive program. At the end of the intensive program the students enter programs in international management or international relations at the university. The subjects were, with one exception, male, ages 25 - 30. As a group they were quite homogeneous in terms of educational background. All attended universities in the upper tier of the Japanese university system and had worked for several years in large Japanese corporations. The subjects TOEFL scores ranged from a high of 620 to a low of 503, the cutoff for subjects in the study.

Materials. Materials for the study consisted of a set of memory tests and a set of measures of reading skill. Three memory tests were used: the Simple Digit; the Simple Word; and the Complex Span Test.

Simple Digit Span. The simple digit span test consisted of eight sets of three strings of random digits. The shortest set consisted of three 2-digit strings. The length of each string increased by 1 digit per set, with the last set comprised of three 9-digit strings. Digits for the strings were generated randomly, with replacement, from a random numbers table.

Simple Word Span. The simple word span test consisted of five sets of three strings of unrelated words. The shortest set consisted of three 3-word strings. The length of each string increased by 1 word per set, with the last set comprised of three 7-word strings. The simple word span test consisted of five sets of three word strings each. Words were randomly drawn from a pretested list of words, though the attempt was made to make the individual words in the string as phonologically dissimilar as possible. For example, we avoided having 'rock' and 'lock,' or 'house' and 'mouse' in the same string.

Complex span test. The complex span test consisted of five sets of sentences. The sentences were simple, active, and 11-13 words in length. Each sentence ended with one of the test words drawn from the list of pretested words. The subject was instructed to read the sentence aloud and then remember the last word. Upon receiving a prompt the subject would then recall as many of the last words as possible. The dependent measure was number of words recalled. In order to assure that the subjects were in fact reading and processing the sentences for meaning, the subjects were also required to check for the grammatical acceptability of the sentence (Turner, et al., 1989). Thus there were two types of sentences, Correct and Incorrect. Sample test sentences are given below.

Pretesting items. Words for the Simple Word Span and Complex Span tests were drawn from a set of 140 high frequency, concrete nouns (West, 1953). The assumption in the word span and complex span is that we are testing the subjects' memorial capacity and not knowledge of the vocabulary item. In order to control for possible effects due to relative vocabulary knowledge, the test items were pretested in a written vocabulary recognition test given to all 43 students in the program (including lower proficiency students not taking part in the study). Adopting the most conservative criterion, we removed any item missed by any of the students.

Test Sentences

Correct:

The clerk in the department store put the presents in a *bag*.

He opened the top drawer and pulled out a clean *shirt*.

Incorrect:

The last thing she did drink a was to hot cup of *tea*.

Two favorite foods in are melon the summer and sweet *corn*.

Correct sentences made semantic and syntactic sense. Incorrect sentences were generated by reversing the last four to six preterminal words. Approximately half of the sentences in each set were randomly selected to be correct and half were incorrect, with the condition that 21 sentences were correct and 21 were incorrect across the entire test set. Either the correct or the incorrect version of the sentence was used. All subjects were tested on the same set of sentences.

Procedure. The Simple Digit Span and Simple Word Span tests were presented on tape at the rate of one digit/word per second. The subjects were tested in a language lab in groups of 10-12. The presentation of the Simple Span test was auditory, in contrast to the Complex Word Span Test in which the subject read the test sentences aloud. Earlier research has shown that auditory word span and visual word span measures correlate almost perfectly (greater than .98)(Daneman, et al., 1980) (Lyon, 1977). Half the subjects did the digit span first and half the subjects did the word span first. Answers were written on an answer sheet that was turned face down while the subjects were listening. At a prompt the subjects would turn the answer sheets over and write down the answer in English. In Simple Word span test the subjects were told that spelling did not important. Digits were recalled in order order of

presentation and words in any order. Practice sets were given for all three tests.

The Complex Word Span test was administered individually. The test sentences were presented on 5 x 7 inch index cards, one sentence per card. The cards were placed one at a time in front of the subject. The subject was instructed to read the sentence in a normal voice and at a normal rate of speaking, but not to backtrack. When the subject finished reading the sentence the experimenter turned the card over and presented a new card. A cue card indicated when the subject should recall the last words of the sentences in the sets. The number of sentences per trial increased by one per set, with each set consisting of three trials. The subject was required to read the sentence aloud and then indicate on the front of the answer sheet whether the sentence was correct by making a check in the appropriate blank. When the cue card was presented the subject turned the answer sheet over and wrote the final word of each sentence. The last words could be recalled in any order and the subjects were told to disregard spelling errors.

TOEFL scores were obtained from the university records. All the scores were from recent TOEFL administrations (2 to 8 months-old). The Nelson-Denny Reading Test was also administered (Nelson, & Denny, 1973). The Nelson-Denny is designed for L1 readers and was used in the present study for comparison purpose. A Cloze test was also administered as a convergent measure of global comprehension. The Cloze test consisted of a 350-word passage from a textbook on international management. Every 7th word was deleted. All three tests were group administered.

Results

Data from the 33 subjects who had scored at least 500 on TOEFL was analyzed. One subject obtained a perfect score on the 132-digit Simple Digit Span test (well over two standard deviations from the mean) and was removed as an outlier. . The Nelson-Denny Reading Test proved to be too difficult for the L2 subjects and was excluded from further analysis. The descriptive statistics for the memory span tests and the other comprehension measures are given in Table 1. Of interest in the present study are the measures of reading ability, as reflected in the the TOEFL Grammar and

Reading sections, and with the Cloze. The TOEFL Listening scores are included for reference purposes. The means and standard deviations for the span measures are comparable to results from the Turner & Engle (1981) study using similar measures with L1 subjects.

Table 1. Descriptive Statistics for Reading and Memory Span Measures

Memory Span Measures:	Mean	SD	Min	Max
Simple digit span	99.4	13.3	76	123
Simple word span	64.4	4.5	55	73
Complex word span	25.2	4.8	16	34
L2 Reading Measures:				
TOEFL 2 (Grammar)	54.9	3.7	47	64
TOEFL 3 (Reading)	54.4	2.9	50	60
350-word Cloze	16.7	4.9	5	27

Correlations. The Simple Digit and Simple Word Span measures did not correlate with the TOEFL measures or with the Cloze. See Table 2. In contrast, the Complex Word Span measure had a significant, moderately strong correlation with all three Reading measures: Complex Word Span and TOEFL Grammar, $r(30) = .44$, $p < .05$; Complex Word Span and TOEFL Reading, $r(30) = .65$, $p < .001$; Complex Word Span and Cloze, $r(30) = .41$, $p < .05$. The correlations are comparable to those obtained in earlier studies with L1 subjects (Daneman, et al., 1980; Daneman, et al., 1986; Turner, et al., 1989).

Table 2. Correlations among Memory and Reading Measures

	Reading Measures		
Memory span measures	TOEFL2 Grammar	TOEFL3 Reading	CLOZE
Simple digit span	.25	.20	.13
Simple word span	.21	.24	.28
Complex word Span	.44*	.65**	.41*

p < .05 *
p < .001 **

n = 32

The strongest correlation is between TOEFL Reading and Complex Word Span. This is to be expected if the Complex Word task is tapping the ability to simultaneously process and store information, skills more heavily tapped in text comprehension than in the discrete point grammar or Cloze tests. However, this can only be considered a trend as the difference between the Grammar and Reading measure correlations were not significant. The Simple Span and TOEFL Reading correlations were both significantly lower than the correlation between the Complex Span and TOEFL Reading. T-tests for differences among dependent correlation coefficients (Glass, & Hopkins, 1984) showed that the Simple Digit-TOEFL Reading correlation was lower than the Complex Word-TOEFL Reading correlation, $t(29) = 2.04$, $p < .05$, and the Simple Word-TOEFL Reading correlation was lower than the Complex Word-TOEFL Reading correlation, $t(29) = 2.11$, $p < .05$.

The simple and complex spans did not intercorrelate. See Table 3. Simple Digit and Simple Word $r(30) = .32$; Simple Digit and Complex Word, $r(30) = .15$; Simple Word and Complex Word, $r(30) = .17$. The correlation of the two simple digits spans did not reach significance, $r(30)$ .32, p .07. If both measures are tapping short-term storage capacity one would expect a stronger correlation as in Turner & Engle (1989), $r = .46$, Daneman & Carpenter, (1980), $r = .55$). The somewhat weaker correlation in the present study may reflect

differences between the subjects in regards to familiarity with the English vocabulary items. This, despite our attempt to control for vocabulary knowledge by pretesting the vocabulary items.

Table 3. Correlations among Complex and Simple Span Memory Measures

	SD	SW	CW
Simple digit span	--		
Simple word span	.32	--	
Complex word span	.15	.17	--

Discussion

The results show that the L2 Complex Word Span measure correlated with measures of L2 reading skill, particularly the TOEFL Reading score. These findings replicate earlier results in the L1 literature and suggest that the Complex Word span can serve as a useful measure in L2 reading development. However, the correlational nature of the results greatly limits the conclusions that can be drawn. If the working memory construct is to be of explanatory value in L2 (or L1) research, it will be necessary to demonstrate a causal, non-circular relationship between working memory capacity and the development of reading skills. The ultimate usefulness of the construct will depend on the degree to which working memory capacity can be established independent of the level of proficiency. In order to address this issue, converging evidence from multiple measures of working memory capacity and reading skill are needed.

Future research needs to examine the way in which capacity limitations affect the development of reading ability. The measures used in the present study reflect general reading comprehension skills and thus it is not clear what aspects of overall reading skill are sensitive to working memory capacity differences. In order to assess how such limitations constrain the development of reading it will be necessary to

understand how the differences in working memory capacity relate to the different subskills that contribute to overall reading ability. Such subskills include understanding pronominal referents, inferring word meaning from context, and reading for gist or specific information. An understanding of the relative sensitivity of the various reading subskills to differences in working memory capacity will allow the development of specific, testable predictions.

The diachronic relationship between working memory capacity and increasing reading skill is also a key issue. It is just as plausible to interpret the main causal variable in the observed relationship between capacity and reading skill as being reading skill rather than working memory capacity. One possible way out of this circularity is obtain longitudinal evidence plotting the development of both factors. Such evidence can be obtained by collecting measures of memory capacity and reading ability at several points in time and then testing causal models representing alternative causal directions (Wagner, & Torgesen, 1987). We are currently involved in this type of research at IUJ. In September 1989 we began a two-year longitudinal study charting the acquisition of Japanese as a second language by foreign students studying in Japan. Over the two-year period we will be profiling the development of Japanese L2 working memory capacity and proficiency in Japanese and assessing the covariance of the two factors.

Finally, cross-linguistic evidence can provide insights both into the development of L2 reading skill and into the processes underlying the working memory construct. At the very least, the inability to replicate findings in a language other than English calls the psychological validity of the index (Complex Span) - and possibly the working memory construct itself - into question. Of greater interest, however, is what the relationships between capacity and ability across the individual's two languages can tell us about the construct and its role in facilitating L2 development.

Although the focus in this paper has been on the role of working memory in the development of L2 reading processes, the relevance of working memory processes to the acquisition and use of other language skills also needs to be explored.

References

Baddeley, A. (1986). *Working Memory*. Oxford: Clarendon Press.

Baddeley, A. D., & Hitch, G. (1974). Working memory. In G. H. Bower (Ed.), *The Psychology of Learning and Motivation*. New York: Academic Press.

Carpenter, P. A., & Just, M. A. (1989). The role of working memory in language comprehension. In D. Klahr, & K. Kotovsky (Ed.), *Complex Information Processing: The Impact of Herbert A. Simon*.Hillsdale, N.J.: Lawrence Erlbaum Associates.

Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior, 19*, 450-466.

Daneman, M., & Carpenter, P. A. (1983). Individual differences in integrating information between and within sentences. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 9*, 561-583.

Daneman, M., & Green, I. (1986). Individual differences in comprehending and producing words in context. *Journal of Memory and Language, 25*, 1-18.

Daneman, M., & Tardif, T. (1987). Working memory and reading skill re-examined. In M. Coltheart (Ed.), *Attention and Performance XII* (pp. 491-508). London: Lawrence Erlbaum Associates.

Glass, G. V., & Hopkins, K. H. (1984). *Statistical methods in education and psychology* . Englewood Cliffs, N. J.: Prentice Hall.

Lyon, D. R. (1977). Individual differences in immediate serial recall: A matter of mnemonics? *Cognitive Psychology, 9*, 403-411.

McLaughlin, B. (1987). *Theories of Second Language Learning* . London: Edwin Arnold.

Miller, G. A. (1956). The magical number seven, plus or minus two: some limits of our capacity for processing information. *Psychological Review, 63,* 81-7.

Nelson, M. S., & Denny, E. D. (1973). *The Nelson-Denny Reading Test* . Boston: Houghton Mifflin.

Oakhill, J., Yuill, N., & Parkin, A. (1986). On the nature of the difference between skilled and less skilled comprehenders. *Journal of Research in Reading, 9,* 80-91.

Perfetti, C. A., & Goldman, S. R. (1976). Discourse memory and reading comprehension skill. *Journal of Verbal Learning and Verbal Behavior, 14,* 33-42.

Pienemann, M., & Johnston, M. (1987). Factors influencing the development of language proficiency. In D. Nunan (Ed.), *Applying Second Language Acquisition Research* (pp. 45-141). Adelaide: National curriculum resource centre.

Skehan, P. (1989). *Individual Differences in Second Language Learning* . London: Edward Arnold.

Turner, M. L., & Engle, R. W. (1989). Is working memory capacity task dependent? *Journal of Memory and Language, 28,* 127-145.

Wagner, R. K., & Torgesen, J. K. (1987). The nature of phonological processing and its causal role in the acquisition of reading skills. *Psychological Bulletin, 101,* 192-212.

Waugh, N. C., & Norman, D. A. (1965). Primary memory. *Psychological Review, 72,* 89-104.

West, M. (1953). *A General Service List of English Words.* London: Longman.

Yuill, N., Oakhill, J., & Parkin, A. (1989). Working memory, comprehension ability and the resolution of text anomaly. *British Journal of Psychology, 80,* 351-361.